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(54) Title: IMPROVEMENTS IN AND RELATING TO OPTICALLY READABLE DISCS AND DISC RECORDING APPARATUS

(57) Abstract

An optical disc and an optical disc recording apparatus have been disclosed, which provide an improved protection against undesired or illegal copying. Information on optical discs is arranged in sectors, which each has an address label. The address value of the address labels increases linearly from the start of the disc or from the start of the program area of the disc. The address labels of specific sectors, which may have an informationless content, are given different, e.g. zero, address values, which prevent copying CD-ROM discs on a standard CD-Recorder apparatus. Said address labels may be stored in the main data stream or e.g. the subcode channel of a CD system.

Layout of copy-protected CD-ROM

Address	Subcode	Track	Index	Content	Comments
000000		1	0	Zero	Start of 130 sectors Program
000001		1	0	Zero	
000002		1	0	Zero	
000003		1	0	Zero	
000004		1	0	Zero	
000005		1	0	Zero	
000006		1	0	Zero	
000007		1	0	Zero	
000008		1	0	Zero	
000009		1	0	Zero	
000010		1	0	Zero	
000011		1	0	Zero	
000012		1	0	Zero	
000013		1	0	Zero	
000014		1	0	Zero	
000015	6	1	1	Zero	First valid sector on CO-205
000016	9	1	1	Zero	
000017	2	1	1	Zero	
000018		1	0	Zero	
000019	13	1	1	Zero	
000020	16	1	1	Par	Primary Volume Descriptor
000021	17	1	1	Par	Primary Volume Descriptor
000022	13	1	1	Zero	No reference to these sectors
000023		1	0	Zero	in the directory of the CO-205
000024	34	1	1	Zero	
000025	30	1	1	Zero	
000026	28	1	1	Zero	
000027	27	1	1	Zero	Address 000027 relating
000028	28	1	1	Zero	Address 000028 relating
000029	29	1	1	Zero	Address 000029 relating
000030	28	1	1	Zero	
000031	28	1	1	Zero	
000032	25	1	1	Zero	
000033		1	0	Zero	
000034	73	1	1	Zero	No reference to these sectors
000035	74	1	1	Zero	in the directory of the CO-205
000036	75	1	1	Zero	
000037	76	1	1	Zero	User data
000038	77	1	1	Zero	User data
000039	78	1	1	Zero	User data
000040		1	1	Zero	User data
000041	82045	1	1	Zero	User data
000042	82046	1	1	Zero	User data
000043	82047	1	1	Zero	User data
000044		1	1	Zero	User data
000045	82049	1	1	Zero	User data
000046	82050	1	1	Zero	User data
000047		1	1	Zero	User data
000048	82052	1	1	Zero	User data
000049	82053	1	1	Zero	User data
000050	82054	1	1	Zero	User data
000051	82055	1	1	Zero	User data
000052	82056	1	1	Zero	User data
000053	82057	1	1	Zero	User data
000054	82058	1	1	Zero	User data
000055	82059	1	1	Zero	User data
000056	82060	1	1	Zero	User data
000057	82061	1	1	Zero	User data
000058	82062	1	1	Zero	User data
000059	82063	1	1	Zero	User data
000060	82064	1	1	Zero	User data
000061	82065	1	1	Zero	User data
000062	82066	1	1	Zero	User data
000063	82067	1	1	Zero	User data
000064	82068	1	1	Zero	User data
000065	82069	1	1	Zero	User data
000066	82070	1	1	Zero	User data
000067	82071	1	1	Zero	User data
000068	82072	1	1	Zero	User data
000069	82073	1	1	Zero	User data
000070	82074	1	1	Zero	User data
000071	82075	1	1	Zero	User data
000072	82076	1	1	Zero	User data
000073	82077	1	1	Zero	User data
000074	82078	1	1	Zero	User data
000075	82079	1	1	Zero	User data
000076	82080	1	1	Zero	User data
000077	82081	1	1	Zero	User data
000078	82082	1	1	Zero	User data
000079	82083	1	1	Zero	User data
000080	82084	1	1	Zero	User data
000081	82085	1	1	Zero	User data
000082	82086	1	1	Zero	User data
000083	82087	1	1	Zero	User data
000084	82088	1	1	Zero	User data
000085	82089	1	1	Zero	User data
000086	82090	1	1	Zero	User data
000087	82091	1	1	Zero	User data
000088	82092	1	1	Zero	User data
000089	82093	1	1	Zero	User data
000090	82094	1	1	Zero	User data
000091	82095	1	1	Zero	User data
000092	82096	1	1	Zero	User data
000093	82097	1	1	Zero	User data
000094	82098	1	1	Zero	User data
000095	82099	1	1	Zero	User data
000096	82100	1	1	Zero	User data
000097	82101	1	1	Zero	User data
000098	82102	1	1	Zero	User data
000099	82103	1	1	Zero	User data
000100	82104	1	1	Zero	User data
000101	82105	1	1	Zero	User data
000102	82106	1	1	Zero	User data
000103	82107	1	1	Zero	User data
000104	82108	1	1	Zero	User data
000105	82109	1	1	Zero	User data
000106	82110	1	1	Zero	User data
000107	82111	1	1	Zero	User data
000108	82112	1	1	Zero	User data
000109	82113	1	1	Zero	User data
000110	82114	1	1	Zero	User data
000111	82115	1	1	Zero	User data
000112	82116	1	1	Zero	User data
000113	82117	1	1	Zero	User data
000114	82118	1	1	Zero	User data
000115	82119	1	1	Zero	User data
000116	82120	1	1	Zero	User data
000117	82121	1	1	Zero	User data
000118	82122	1	1	Zero	User data
000119	82123	1	1	Zero	User data
000120	82124	1	1	Zero	User data
000121	82125	1	1	Zero	User data
000122	82126	1	1	Zero	User data
000123	82127	1	1	Zero	User data
000124	82128	1	1	Zero	User data
000125	82129	1	1	Zero	User data
000126	82130	1	1	Zero	User data
000127	82131	1	1	Zero	User data
000128	82132	1	1	Zero	User data
000129	82133	1	1	Zero	User data
000130	82134	1	1	Zero	User data
000131	82135	1	1	Zero	User data
000132	82136	1	1	Zero	User data
000133	82137	1	1	Zero	User data
000134	82138	1	1	Zero	User data
000135	82139	1	1	Zero	User data
000136	82140	1	1	Zero	User data
000137	82141	1	1	Zero	User data
000138	82142	1	1	Zero	User data
000139	82143	1	1	Zero	User data
000140	82144	1	1	Zero	User data
000141	82145	1	1	Zero	User data
000142	82146	1	1	Zero	User data
000143	82147	1	1	Zero	User data
000144	82148	1	1	Zero	User data
000145	82149	1	1	Zero	User data
000146	82150	1	1	Zero	User data
000147	82151	1	1	Zero	User data
000148	82152	1	1	Zero	User data
000149	82153	1	1	Zero	User data
000150	82154	1	1	Zero	User data
000151	82155	1	1	Zero	User data
000152	82156	1	1	Zero	User data
000153	82157	1	1	Zero	User data
000154	82158	1	1	Zero	User data
000155	82159	1	1	Zero	User data
000156	82160	1	1	Zero	User data
000157	82161	1	1	Zero	User data
000158	82162	1	1	Zero	User data
000159	82163	1	1	Zero	User data
000160	82164	1	1	Zero	User data
000161	82165	1	1	Zero	User data
000162	82166	1	1	Zero	User data
000163	82167	1	1	Zero	User data
000164	82168	1	1	Zero	User data
000165	82169	1	1	Zero	User data
000166	82170	1	1	Zero	User data
000167	82171	1	1	Zero	User data
000168	82172	1	1	Zero	User data
000169	82173	1	1	Zero	User data
000170	82174	1	1	Zero	User data
000171	82175	1	1	Zero	User data
000172	82176	1	1	Zero	User data
000173	82177	1	1	Zero	User data
000174	82178	1	1	Zero	User data
000175	82179	1	1	Zero	User data
000176	82180	1	1	Zero	User data
000177	82181	1	1	Zero	User data
000178	82182	1	1	Zero	User data
000179	82183	1	1	Zero	User data
000180	82184	1	1	Zero	User data
000181	82185	1	1	Zero	User data
000182	82186	1	1	Zero	User data
000183	82187	1	1	Zero	User data
000184	82188	1	1	Zero	User data
000185	82189	1	1	Zero	User data
000186	82190	1	1	Zero	User data
000187	82191	1	1	Zero	User data
000188	82192	1	1	Zero	User data
000189	82193	1	1	Zero	User data
000190	82194	1	1	Zero	User data
000191	82195	1	1	Zero	User data
000192	82196	1	1	Zero	User data
000193	82197	1	1	Zero	User data
000194	82198	1	1	Zero	User data
000195	82199	1	1	Zero	User data
000196	82200	1	1	Zero	User data
000197	82201	1	1	Zero	User data
000198	82202	1	1	Zero	User data
000199	82203	1	1	Zero	User data
000200	82204	1	1	Zero	User data
000201	82205	1	1	Zero	User data
000202	82206	1	1	Zero	User data
000203	82207	1	1	Zero	User data
000204	82208	1	1	Zero	User data
000205	82209	1	1	Zero	User data
000206	82210	1	1	Zero	User data
000207	82211	1	1	Zero	User data
000208	82212	1	1	Zero	User data
000209	82213	1	1	Zero	User data
000210	82214	1	1	Zero	User data
000211	82215	1	1	Zero	User data
000212	82216	1	1	Zero	User data
000213	82217	1	1	Zero	User data
000214	82218	1	1	Zero	User data
000215	82219	1	1	Zero	User data
000216	82220	1	1	Zero	User data
000217	82221	1	1	Zero	User data
000218	82222	1	1	Zero	User data
000219	82223	1	1	Zero	User data
000220	82224	1	1	Zero	User data
000221	82225	1	1	Zero	User data
000222	82226	1	1	Zero	User data
000223	82227	1	1	Zero	User data
000224	82228	1	1	Zero	User data
000225	82229	1	1	Zero	User data
000226	82230	1	1	Zero	User data
000227	82231	1	1	Zero	User data
000228	82232	1	1	Zero	User data
000229	82233	1	1	Zero	User data
000230	82234	1	1	Zero	User data
000231	82235	1	1	Zero	User data
000232	82236	1	1	Zero	User data
000233	82237	1	1	Zero	User data
000234	82238	1	1	Zero	User data
000235	82239	1	1	Zero	User data
000236	82240	1	1	Zero	User data
000237	82241	1	1	Zero	User data
000238	82242	1	1	Zero	User data
000239	82243	1	1	Zero	User data
000240	82244	1	1	Zero	User data
000241	82245	1	1	Zero	User data
000242	82246	1	1	Zero	User data
000243	82247	1	1	Zero	User data
000244	82248	1	1	Zero	User data
000245	82249	1	1	Zero	User data
000246	82250	1	1	Zero	User data
000247	82251	1	1	Zero	User data
000248	82252	1	1	Zero	User data
000249	82253	1	1	Zero	User data
000250	82254	1	1	Zero	User data
000251	82255	1	1	Zero	User data
000252	82256	1	1	Zero	User data
000253	82257	1	1	Zero	User data
000254	82258	1	1	Zero	User data
000255	82259	1			

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Improvements in and relating to optically readable discs and disc recording apparatus.

The invention relates to disc recording apparatus for recording digital data on an optically readable disc. The invention further relates to optically readable discs on which such digital data have been recorded, and playback apparatus for such discs.

5

A system using an optically readable digital audio disc (referred to as a compact disc) is a disc system which can reproduce high quality stereophonic musical sounds. Such system is known from the International Standard IEC 908: "Compact Disc Digital Audio System". Digital data such as data representative of characters, display data,
10 program software, computer data, images, etc. other than stereophonic musical sounds can be stored on and reproduced by such a disc system without markedly modifying the arrangement of the player for such disc. A playback apparatus for reproducing visual information such as charts and statistics using graphics, pictorial illustration using still pictures, and a video game apparatus by adding a display unit, have been realized thereby
15 providing a wide range of use for a compact disc system. The data memory capacity of the current compact disc is about 640 Mbytes, and therefore, a compact disc has a very large advantage as compared with the memory capacity of a standard flexible disc. Such CD systems are known as the CD-ROM system and are known amongst others from the ECMA standard - 130 and 168 respectively: "Data Interchange on Read Only 120mm Optical Data
20 Disks (CD-ROM)" and "Volume and File Structure of Read only and Write Once Compact Disc Media for Information Exchange" respectively.

A drawback of the optically readable discs is that they can be copied easily. Although there is a copy protect bit used in each group of frames of a CD-Audio disc in the subcode channel, still undesired copying is possible, because this bit has a fixed
25 repetitive position in the bitstream provided by the output of the decoder in a CD-player, and thus can easily be "overruled". Further, software programs for PC applications etc. are distributed by use of CD-ROM discs in vast amounts. Here again it is highly desirable that copying can not be done without permission/authorization. Also a lot of other formats of optically readable discs are gaining commercial interest and thus anti-copy measures are

highly desirable.

It is an object of the invention to provide an optically readable disc, which
5 has an improved protection against undesired or illegal copying by use of an optical disc
recording apparatus. It is a further object of the invention to provide an optically readable
disc for any type of compact disc system, which has an improved protection against
undesired and or illegal copying of such discs by use of CD-recording apparatus, which are
already available in the market.

10 It is another object of the invention to provide an optical disc recording
apparatus, which has an improved capability to prevent undesired and or illegal copying of
optically readable discs in addition to the todays anti copy mechanisms.

According to a first aspect of the invention there is provided an optically
readable disc comprising digital data being arranged in sectors corresponding to a unit of
15 organisation of the digital data and each sector being accessible via an address label stored
with said sector, characterized in that the address label has an address value increasing with
each successive sector except for at least one address label, which has a address value
different from the increasing address value. This has the advantage, that such address values
cannot be created using a standard optical recording apparatus.

20 A preferred embodiment of the optically readable disc, wherein the digital
data comprises digital mainstream data and digital subcode data, is characterized in that the
address label having said different address value is stored in the digital subcode data. This is
advantageous in that the subcode data cannot be controlled directly on a recording apparatus.

A further embodiment of the optically readable disc is characterized in
25 that the address label having said different address value is stored with a sector containing
informationless data. This has the advantage, that no special reading device is needed for
reading the sectors having the different address values.

A further embodiment of the optically readable disc is characterized in
that said different address value is a zero address value.

30 A further embodiment of the optically readable disc is characterized in
that a multiple of successive address labels have said different address value.

A further embodiment of the optically readable disc, wherein the sectors
are arranged in a program area starting with a pregap comprising sectors with
informationless data, is characterized in that at least one address label having said different

address value, is arranged in the pregap.

A further embodiment of the optically readable disc, wherein the sectors are arranged in a program area preceded by lead-in area and succeeded by a lead-out area, is characterized in that at least one address label having said different address value is arranged in the lead-in area and/or the lead-out area.

A further embodiment of the optically readable disc is characterized in that at least one address label which has said different address value is arranged preceding or succeeding a sector storing copy-protectable information.

A further embodiment of the optically readable disc, on which the digital data is stored according to predetermined modulation and error correction rules, is characterized in that at least one sector comprises at least one error effected by violating the predetermined modulation and error correction rules.

According to a second aspect of the invention there is provided an optical disc recording apparatus for recording digital data on an optically readable disc, the digital data being arranged in sectors and each sector being addressable via an address label, which address label has an address value increasing with each successive sector, characterized in that the optical disc recording device comprises reading means for reading address labels, detection means for detection of an address label, which has a address value different from the increasing address value relative to the address value of the preceding address label, and abortion means for aborting the recording of digital data upon detection of said address label, which has said different address value.

According to a third aspect of the invention there is provided an optical disc playback apparatus for retrieving digital data from an optically readable disc, the digital data being arranged in sectors and each sector being addressable via an address label, characterized in that the optical disc playback device comprises verification means for verifying an address label, which has an address value different from the address value increasing relative to the address value of the preceding address label, and abortion means for aborting the playback of digital data in dependence upon the verification.

The invention will be illustrated, by way of an example, with reference to the drawings, in which

Figures 1 and 2 are schematic diagrams which are used to describe the data arrangements of the recorded data of a compact disc to which this invention is applied;

Figure 3 is a schematic diagram showing the arrangement of one block of the digital main data in one embodiment of this invention;

Figure 4 is a block diagram of apparatus in accordance with this invention;

5 Figure 5 is a schematic diagram showing a word format of serial data produced in this apparatus;

Figure 6 shows a schematic diagram of the layout of a CD-ROM disc as a function of time;

10 Figure 7 shows in a matrix a schematic diagram a table of addresses, sector numbers, tracks and content of CD-ROM disc as a function of time in accordance with the invention;

Figure 8 shows a schematic diagram of the layout of the sector organisation of a another optical disc; and

15 Figure 9 shows schematically an optical disc recording apparatus in accordance with the invention.

Figure 1 shows the data stream recorded on a compact disc. One frame Fr consists of 588 bits of recorded data, and each frame has at its head a frame sync pulse FS of a specific bit pattern. The frame sync pulse FS is followed by a 3-bit DC-restriction word RB. Thereafter, the 0th - 32nd data words DB each having 14 bits and the 3-bit DC-restriction words RB are further recorded alternately. The 0th words among these data words DB are subcode data (or so-called user bytes) of a subcode signal which is used to control the playback of a disc and to display the relating information or the like. In the audio disc format, the 1st to 12th and 17th to 28th data words DB are assigned for audio data in the main channel. The remaining 13th to 16th and 29th to 32nd data words DB are assigned for parity data of the error correction code in the main channel. Each of the data words DB consists of 14 bits into which 8-bit data has been converted by a 8 to 14 conversion upon recording.

30 Figure 2 shows the state of data in one group of the frames (98 frames), with the 98 frames arranged sequentially in parallel. In Figure 2, each of the data words D3 is represented by 8 bits and the DC-restriction words RB are excluded. The subcode signal data P to W in the 0th and 1st frames form the sync patterns which are predetermined bit patterns. For the Q channel, the CRC codes for error detection are inserted in the latter 16

frames among the 98 frames.

The P-channel signal is a flag to indicate a music program and a pause. With music recorded in audio disc format, this signal in the P-channel has a lower level throughout the duration of a music program and a higher level throughout the duration of a pause, and has pulses of 2-Hz period in the lead-out section. It is possible to select and play back the specified music program by detecting and counting this signal in the P channel. The Q channel enables more complicated control of this type. For example, when the Q-channel information is stored in a microcomputer in the disc playback apparatus, it is possible to shift quickly from one music program to another during the playback of a music program; thus, 10 respective ones of the recorded music programs may be selected at random. The other R through W channels can be used to indicate an author or composer, an explanation, poetry, or the like for the music programs recorded on the disc.

Among the 98 bits in the Q channel, the first two bits are used for a sync pattern; the next four bits for control bits; then the next four bits for address bits; the 15 following 72 bits for data bits; and at last a CRC code for error detection is added. A track number code TNR and an index code X are included in 72 bits representative of the data bits. The track number code TNR can be varied from 00 to 99, and the index code X can be likewise changed from 00 to 99.

20 Furthermore, the data in the Q channel contains a time indication code representative of the time durations of music programs and pauses, and a time indication code indicative of an absolute time duration that continuously changes from the beginning to the end on the most outer rim side in the program area of the compact disc. These time indications codes comprise the codes indicating minute, second and frame which each consist 25 of two digits. One second is divided into 75 frames. In order to access digital data from the compact disc on a shorter unit basis than a music unit, the time indication code with respect to the above-mentioned absolute time duration is used in this embodiment of the present invention.

Figure 3 illustrates an arrangement of digital signals other than 30 stereophonic musical signals from the compact disc in an embodiment of the present invention. As described above, the subcode signal for a compact disc is organised in units of 98 frames. In this embodiment of Figure 3, one block of the main data is constituted by the length of 98 frames corresponding to the same group of the 0th to 97th frames. In the audio disc format, one frame includes the digital audio data consisting of 12 words each of 16 bits,

and so 24-byte digital main data can be inserted in one frame. Referring to Figure 3, one row contains total 32 bits of one sample in the L channel of the audio data and one sample in the R channel thereof, and each frame consists of six such rows.

In the embodiment of Figure 3, a one-bit sync bit is added to the head of each 32-bit row of the block. In the 0th frame F_0 the sync bits at the respective heads of the first 32 bits and the next 32 bits are zero. The sync bits in each head of the respective first 32 bits in the frames bearing even numbers except the 0th frame are zero, while the sync bits in each head of the respective first 32 bits in the frames bearing odd numbers are one. These sync bits enable the detection of the head location of the block on a 98-frame unit basis.

The above-mentioned one block consists of $(24 \text{ bytes} \times 98 = 2352 \text{ bytes})$. The data of 2 Kbytes (2048 bytes) is inserted in one block, and 304 bytes (2432 bits) remain. $(6 \times 98 = 588 \text{ bits})$ are used as sync bits. A 7-bit mode signal and a 24-bit address signal are inserted in the first 32 bits in the 0th frame, so that 1813 bits still remain in one block. These 1813 bits can be assigned to redundant bits when the error correction coding processing is performed for the data of one block.

The mode signal serves to specify the kind of data in that block. For example, the mode signal is used to discriminate character data, still picture data and program code. The address signal serves to specify the data in the block. Furthermore, the reason why the sync bits of the frame bearing even numbers are set to zero is that the present embodiment of the invention takes account of an arrangement of data block on a two-frame unit basis. For the block having a size of two frames, a mode signal and an address signal are added to each block. In the case of the block having a length of 98 frames as in the Figure 3 embodiment of this invention, the codes for indicating the P data and the absolute time durations of the Q data in the subcode signals in the same block are identical.

The digital signals in the block format shown in Figure 3 can be recorded on a compact disc in the same manner as an audio compact disc. That is, a digital signal to be recorded is supplied to a digital input terminal of a digital audio processor and this digital signal is converted into a video signal format, thereby recording it using a VTR system of the rotary head type. In this case, TOC (table of contents) data to generate a subcode signal is preliminarily recorded in the audio track in the starting edge section on a magnetic tape on which this digital signal will be recorded. Next, the TOC data reproduced from this magnetic tape is supplied to a subcoding generator, and the reproduced digital signal is supplied to an encoder, and the subcode signal is further supplied to this encoder, then a laser beam is

modulated on the basis of an output of the encoder. A master disc is made by means of this modulated laser beam.

As another method of recording a digital signal, the data stored on, for example, a hard disc memory that can be accessed at a high speed is accessed by a minicomputer, and a digital signal is supplied in real time to an encoder of a cutting system.

Figure 4 shows a playback apparatus in accordance with this invention. In Figure 4, reference numeral 1 denotes a compact disc on which a digital signal of the above-described format has been spirally recorded. The compact disc 1 is rotated by a spindle motor 2. In this case, the spindle motor 2 is controlled by a spindle servo circuit 3 so that the compact disc 1 rotates at a constant linear velocity.

Reference numeral 4 indicates an optical head, which has a laser source for generating a laser beam for pickup, a beam splitter, an optical system such as an objective lens or the like, and a photoreceptive device for receiving the reflected laser beam from the compact disc 1, etc. The optical head 4 can be moved in the radial direction of the compact disc 1 by the thread feed motor 5. The thread feed motor 5 is driven by a thread drive circuit 6. The optical head 4 can be deflected both in the direction perpendicular to the signal surface of the compact disc 1 and in the direction parallel thereto, and it is controlled so that the focusing and tracking of the laser beam upon playback are always properly performed. For this purpose, a focusing and tracking servo circuit 7 is provided.

A reproduction signal from the optical head 4 is supplied to an RF amplifier 8. The optical head 4 is provided with a focus error detecting section consisting of a combination of, for example, cylindrical lens and 4-dividing detector, and a tracking error detecting section using three laser spots. This servo error signal is supplied to a focusing and tracking servo circuit 7. An output signal of the RF amplifier 8 is supplied to a digital demodulator 9 and a bit clock reproduction circuit 10. The digital signal recorded on the compact disc 1 has been EFM modulated. The EFM modulation is a method of block-converting 8-bit data into a preferable 14-bit (i.e. 14 bits such as to provide a long minimum inverting time period of the modulated signal and reduce its low-frequency component) pattern. The digital demodulator 9 is constituted in such a manner as to carry out the demodulation of EFM. The bit clock fetched by a bit clock reproduction circuit 10 is supplied to the digital demodulator 9 and the spindle servo circuit 3.

The subcode signal is separated by the digital demodulator 9 and this separated subcode signal is supplied to a system controller 11. The system controller 11 is equipped with a CPU, and the rotating operation of the compact disc 1, the thread feeding

operation, the reading operation of the optical head 4, or the like are controlled by the system controller 11. Control commands are supplied to the system controller 11 through an interface 17, that will be described later. Namely, the reading operation of a desired digital signal from the compact disc 1 using the subcode signal is controlled by the system controller 11.

The main digital data output from the digital demodulator 9 is supplied through a RAM controller 12 to RAM 13 and an error correction circuit 14. The processing with respect to the elimination of variation of the time base, error correction and error interpolation are carried out by the RAM controller 12, RAM 13 and error correction circuit 14, so that the digital main data is fetched from terminals 15L and 15R. In the case of playback of a compact disc on which only audio data has been recorded, D/A converters would be connected to these terminals 15L and 15R, respectively. In the case of Figure 4, no D/A converter is provided to fetch the digital data from the outputs, and the reproduced digital data is supplied to a data converter 16. The reproduced subcode signal is also supplied to this data converter 16, and the reproduced data is converted into the form of a serial signal.

This serial signal is supplied to the interface 17, and the data for the system controller 11 is supplied from a microcomputer system 18 through the interface 17 to the controller 11. The microcomputer system 18 specifies a readout address and applies control signals such as start signals in addition to this readout address to the interface 17 and system controller 11. A list of a plurality of record areas has been recorded in the lead-in track in the most inner rim section on the compact disc 1 using the subcode signal as addresses. This list is reproduced in the initial state to start the readout of the compact disc 1 and is read by the microcomputer system 18.

Figure 5 shows an example of the word format of the serial signal output from the data converter 16. For this serial signal, one word consists of 32 bits; the first four bits are for preamble; next four bits for auxiliary bits of the audio data; and next 20 bits for digital audio sample. In the case where the digital audio sample consists of 16 bits, 16 bits from the least significant bit (LS8) are inserted. Four bits are added after the digital audio sample. Among these four bits, the first bit indicated by V is a flag to show whether the digital audio sample of that word is effective or not; bit U is each bit of the subcode signal; bit C is a bit to identify the channel; and bit P is a parity bit. This bit U of the subcode signal is inserted into each word format one bit by one and these inserted bits are sequentially transmitted.

In one embodiment of the present invention, a read instruction to a predetermined address is first executed by the microcomputer system 18. This address is a code itself for indicating an absolute time duration in the Q channel and is supplied through an interface 17 to the system controller 11. The system controller 11 controls the thread drive circuit 6 to move the optical head 4 to the location near a desired pickup location while supervising the subcode signal reproduced by the optical head 4. In this example, therefore, the reproduction is started from the location spaced a few blocks apart to prevent a malfunction due to the access operation being not finished if an error occurred in the reproduced subcode signal and the set subcode signal is not reproduced. The desired block is caught by detecting the coincidence of the reproduced subcode signal with the designated address, or by starting the playback from the location near the correct subcode signal and then counting the frame sync signals.

In fig. 6 a schematic layout of a CD-ROM disc in accordance with the invention has been shown. Reference is made herewith to the ECMA-Standard 130 (CD-ROM-Standard) Section IV: Recording, which is incorporated in here for purpose of reference.

The information area IA on a disc comprises at least a lead-in area LI, a program area PG and a lead-out area LO. The track number TNO, which is recorded in the Q-channel of the subcode channel, has the value OO and AA respectively for the lead-in area LI and the lead-out area LO respectively.

The program area PG has been divided in a plurality of tracks. In this example the CD-ROM disc comprises CD-Audio tracks as well as CD-ROM data tracks. The four tracks as shown have the successive track numbers, 01, 02, 03 and 04 and are an audio track, a ROM track, a ROM track and an Audio track respectively. The index belonging to track number TNO, each time has the value 00 during a pregap, which comprises informationless data e.g. the value 00 (in Hexadecimal notation). The index has the value 01 during the groups of frames (sectors) comprising information such as audio or ROM DATA.

In the subcode data time references have been recorded. A first time reference TIME relates to the information in the track. Each time at the start of the information in a track the time reference TIME starts at a value zero and increases linearly with the successive groups of frames in a track. Further the time reference TIME starts at a certain value at the start of a pregap and decreases linearly with the successive groups of frames, which comprise informationless data (e.g. "digital silence"), and ends at the value zero at the end of the pregap.

Further an absolute time code ATIME has been recorded in the Q channel of the subcode data. This absolute time code ATIME has a zero value at the beginning of the program area PG and increases linearly with the groups of frames in the program area PG.

In accordance with a first embodiment of the invention in the pregap 1 there have been
5 recorded absolute time codes that do not comply with the linear increasing values of ATIME, e.g. the value zero can be recorded as indicated by zero sector address ZSA1.

The ROM data in the CD-ROM tracks (TNO = 02 or TNO = 03) are accessible by address labels that have been recorded in the main stream data. These ROM-Sector Header Addresses have the same value as the absolute time code ATIME in the Q
10 channel corresponding to the same sectors (groups of frames) as shown in figure 6. In another embodiment of the invention certain ROM Sector Header Addresses have been set to zero beyond pregap 2, TNO = 02; INDEX = 01. Again this is a violation of the linearly increasing absolute time code ATIME and the ROM Sector Heading Addresses corresponding therewith.

15 In fig. 7 a table of sector addresses ADD, sector numbers SN, track numbers TNO, index numbers INDEX and content has been shown. The sector address 00:00:00 first occurring in the very first address of the Program Area PG (see Fig. 6). The sector addresses ADD increases linearly during the 150 sector of the pregap. (from 00:00:00 to 00:00:74 for the first 75 sectors and from 00:01:00 to 00:01:74 for the second 75 sectors).
20 The first part of the CD-ROM track 1 comprises sectors, which may comprise information start at sector SN=0 at address 00:02:00. In accordance with the invention sectors 27, 28 and 29 each have an address ADD equal to 00:00:00, which violates the linear increasing sequence of addresses. The content of the sectors 27, 28, 29 are informationless. These sectors 27, 28 and 29 have been preceded by sectors that do have information, e.g. sectors
25 16 and 17 contain the Primary Volume descriptor for this CD-ROM discs. The sectors SN = 18 to SN = 74 do not have information and are not referred to in the directory of the CD-ROM. Sector SN = 75 and succeeding sectors up to 355.349 provide the CD-ROM user data, which end at the postgap of sectors 355.350 to 355.499. The next sector is the start of the lead-out area, which is shown by track number TNO = AA.

30 In fig. 8 another embodiment of a layout of an optically readable disc in accordance with the invention has been shown. The disc shows an information area, a lead-in area and a lead-out area. The lead-in area comprises several blocks, each comprising the same number of sectors (e.g. a block comprises 16 sectors). A number of Start Blocks SB all comprise informationless data. Reference code blocks RB may comprise information for

error correction of the Start Blocks SB. Intermediate Blocks IB1 again may comprise informationless data. In a next part of the Lead-In Area several control blocks CB are present, which may comprise information about the disc, discmanufacturer etc. Intermediate Blocks IB2 follow the Control Blocks CB, precede the Data Area DA and comprise informationless sectors. Sector number addresses start with address $SN = 0$ at start of the lead-in area and end with address $SN = n$ for the last sector of the lead-out area. The sector addresses increase linearly from 0 to n for each sector therebetween, except for a few sectors in e.g. intermediate blocks IB1 or IB 2. These few sectors have sector address labels, which have an address value different from the increasing value, e.g. a zero address value. As a result undesired copying is prevented.

It should be emphasized that the sector addresses, which should violate the linear increasing sequence of the address values can be arranged at random in the specified areas, so as to increase the threshold of undesired/illegal copying of discs.

Fig. 9 by way of example shows an embodiment of an information recording device in accordance with the invention. The present embodiment is a recording device by means of which information can be recorded on a record carrier 91, for example an optical record carrier, which is rotated about an axis 92. The information recording device comprises a customary read/write head 93, arranged opposite the rotating record carrier 91. By means of a customary positioning system for example in the form of a motor 94 and a spindle 95a, the read-write head 93 can be moved in a radial direction relative to the record carrier 91 under control of a customary control unit 95, which comprises for example a microprocessor.

An information signal V_i to be recorded can be applied to a signal processing circuit 97 via an input 96. The signal processing circuit 97 is of a customary type, which converts the applied input signal into a recording signal V_{op} is applied to a driver circuit 98 of a customary type, which converts the recording signal V_{op} into a drive signal V_s for the read/write head 93 in such a way that an information pattern corresponding to the recording signal V_{op} is recorded on the record carrier. For the purpose of reading the recorded information patterns the read/write head 93 has an output for supplying a read signal V_1 which is representative of the information pattern being read. The read signal V_1 is applied to a read circuit 99 for recovering the information presented by the read signal V_1 . The driver circuit 98 is of an adjustable type, enabling one or more of the parameters with which the quality of the recorded information pattern can be influenced to be adjusted. When an optical read/write head is used by which an information pattern of optically detectable

effects is formed by means of a radiation beam, the intensity of the radiation beam is an important parameter which largely dictates the quality of the information pattern. If the read/write head is a magnetic or magneto-optical write head which generates a magnetic field for the purpose of forming an information pattern in the form of magnetic effects (domains), the field strength of the generated magnetic field may be an important adjustment parameter. If the information patterns is formed by means of write pulses the pulse width may be an important adjustment parameter. It is to be noted that the above-mentioned adjustment parameters are only few examples of the large number of adjustment parameters which are possible. In this respect reference is made in particular to NL-A-9000150 (PHN 13.217), in which the adjustment parameter is a reference value for the speed with which the effects are formed at the adjusted reference value.

For determining the optimum setting of the driver circuit 98 the device comprises an analysis circuit 910, which derives from the read signal an analysis signal V_a which is indicative of the quality of the information pattern being read. The optimum setting can be determined in a calibration procedure by forming test information patterns for different settings of the driver circuit on the record carrier 91 and by selecting on the basis of the analysis signal V_a that setting for which the analysis signal indicates an optimum quality. In principle, the information signal V_i may be employed for writing the test information pattern. However, it is also possible to employ a test signal generator 911 for this purpose, which may then be included, for example, in the signal processing circuit 97. The optimum setting is determined under control of the control unit 915, which for this purpose is coupled to the analysis circuit 910, to the driver circuit 98, and to the test signal generator 911, if present, which control unit is loaded with a suitable program or comprises a suitable hardware circuit. Preferably, the optimum setting is determined in a calibration procedure, which is carried out after a record carrier has been inserted in the information recording device.

Further the information recording device has a digital input 96D for receiving digital signals D_i in accordance with international Standards or de-facto standards, such as CD-Audio Signals, CD-ROM signals etc. This input 96D is connected directly to the input of driver circuit 98, because the digital signals are alike to the digital recording signal V_{op} generated by the processing circuit 97.

The digital input signal D_i is further read by reading means 97A, which read the address labels either from the digital main-stream data or from the subcode data and provides the same to the detection means 97B. Upon detection by the detection means 97B of an address label having a zero address value in succession of an address label having a non-

zero address value the detection means 97B trigger abortion means 97C, which aborts recording of the digital input signals Di by setting the driver circuit 98 into a non-operative condition. Preferably the means 97A, 97B and 97C and the driver circuit 98 are integrated in a single integrated circuit.

5 The playback apparatus according to the invention is arranged for retrieving the digital data from the optical disc as described with Figure 4. Before the user actually is given access to the digital data, a verification process is executed. The presence of at least one of the address labels having said different address value is verified, e.g. by reading the sector of which the address label is known to be different. If the reading response shows an error, the
10 presence of the different address value is detected, and if the response shows a normal sector, the different address value is absent. The value of the address label may also be verified directly by reading means arranged for reading the address label, such as described above with Figure 9. In dependence upon the verification the playback of the digital data is aborted, i.e. in the case that one or more of the different address values are absent. Illegal copies of
15 the optical disc may comprise some or all digital data of the sectors having the normal, increasing address values. However the illegal copies will not have the sectors having address labels with said different address values, as such labels cannot be recorded using standard recording equipment. The verification may be a build in verification procedure in the playback apparatus, e.g. verifying some sectors with fixed addresses. Alternatively the
20 addresses of sectors to be verified may be stored on the optical disc in a normally readable sector. However in a preferred embodiment of the playback apparatus, the verification procedure is part of the digital data stored on the optical disc and is loaded from the optical disc in a programmable part of the playback apparatus when the optical disc is entered in the apparatus. For an optical disc comprising computer software, e.g. a CD-ROM, the
25 verification procedure preferably is an integral part of the computer software the user will activate.

 In a further embodiment of the optically readable disc at least one sector is provided with other errors instead of or in addition to said different address value. In a CD the channel code EFM is used as described above with Figure 4. The errors may be effected
30 by modifying the EFM channel bit patterns into non permitted patterns of channel bits or by violating other modulation or error correction rules. For example for EFM a minimum (d) and maximum (k) number of channel bit periods between each transition of logical value is given, the so called d,k constraint. If the d,k constraint is violated, the EFM decoder certainly will report errors. A reading device will produce an read error message when

reading such a sector having errors, and a standard recording device cannot record such errors. In a preferred embodiment the sectors comprising other errors are arranged adjoining sectors having only the different address value, as it will be difficult to detect which are the sectors having the different address values and which are the sectors comprising the other errors, as the reading will be influenced by the combined effects of the adjoining sectors.

A malicious party faces various difficulties in creating an operative illegal copy. The playback apparatus is not able to read the sectors having said different address values and/or the sectors comprising the other errors, and will generate read errors. A recording apparatus may be forced by the malicious party to replace such sectors by dummy sectors.

10 However a standard recording apparatus cannot create the different address values or the other errors, while in operation the absence thereof will be detected on the playback apparatus. Modifying the standard recording device to create said different address values is difficult. Modifying the standard recording device even further to create the other errors is even more difficult. Therefore in practical circumstances an operative copy cannot be made.

CLAIMS:

1. An optically readable disc comprising digital data being arranged in sectors corresponding to a unit of organisation of the digital data and each sector being accessible via an address label stored with said sector, characterized in that the address label has an address value increasing with each successive sector except for at least one address label, which has a address value different from the increasing address value.
5
2. An optically readable disc as claimed in claim 1, wherein the digital data comprises digital mainstream data and digital subcode data, characterized in that the address label having said different address value is stored in the digital subcode data.
3. An optically readable disc as claimed in claim 1 or 2, characterized in that
10 the address label having said different address value is stored with a sector containing informationless data.
4. An optically readable disc as claimed in claim 1 or 2, characterized in that said different address value is a zero address value.
5. An optically readable disc as claimed in claim 1, characterized in that a
15 multiple of successive address labels have said different address value.
6. An optically readable disc as claimed in claim 1, wherein the sectors are arranged in a program area starting with a pregap comprising sectors with informationless data, characterized in that at least one address label having said different address value is arranged in the pregap.
- 20 7. An optically readable disc as claimed in claim 1, wherein the sectors are arranged in a program area preceded by lead-in area and succeeded by a lead-out area, characterized in at at least one address label having said different address value is arranged in the lead-in area and/or the lead-out area.
8. An optically readable disc as claimed in claim 1, characterized in that at
25 least one address label which has said different address value is arranged preceding or succeeding a sector storing copy-protectable information
9. An optically readable disc as claimed in claim 1, on which the digital data is stored according to predetermined modulation and error correction rules, characterized in that at least one sector comprises at least one error effected by violating the predetermined

modulation and error correction rules.

10. An optical disc recording apparatus for recording digital data on an optically readable disc, the digital data being arranged in sectors and each sector being addressable via an address label, which address label has an address value increasing with
5 each successive sector, characterized in that the optical disc recording device comprises reading means for reading address labels, detection means for detection of an address label, which has a address value different from the increasing address value relative to the address value of the preceding address label, and abortion means for aborting the recording of digital data upon detection of said address label, which has said different address value.

10 11. An optical disc playback apparatus for retrieving digital data from an optically readable disc, the digital data being arranged in sectors and each sector being addressable via an address label, characterized in that the optical disc playback device comprises verification means for verifying an address label, which has an address value
15 address label, and abortion means for aborting the playback of digital data in dependence upon the verification.

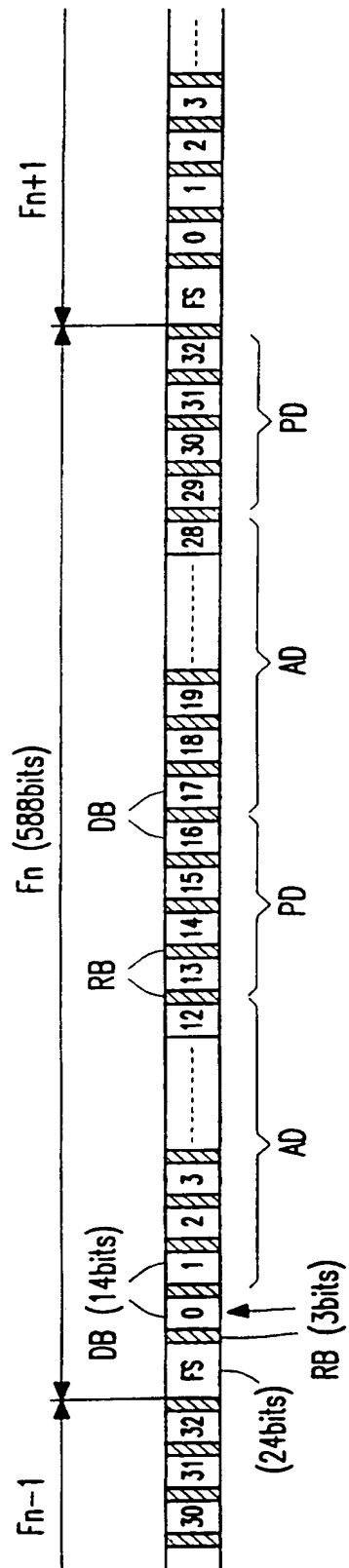


FIG. 1

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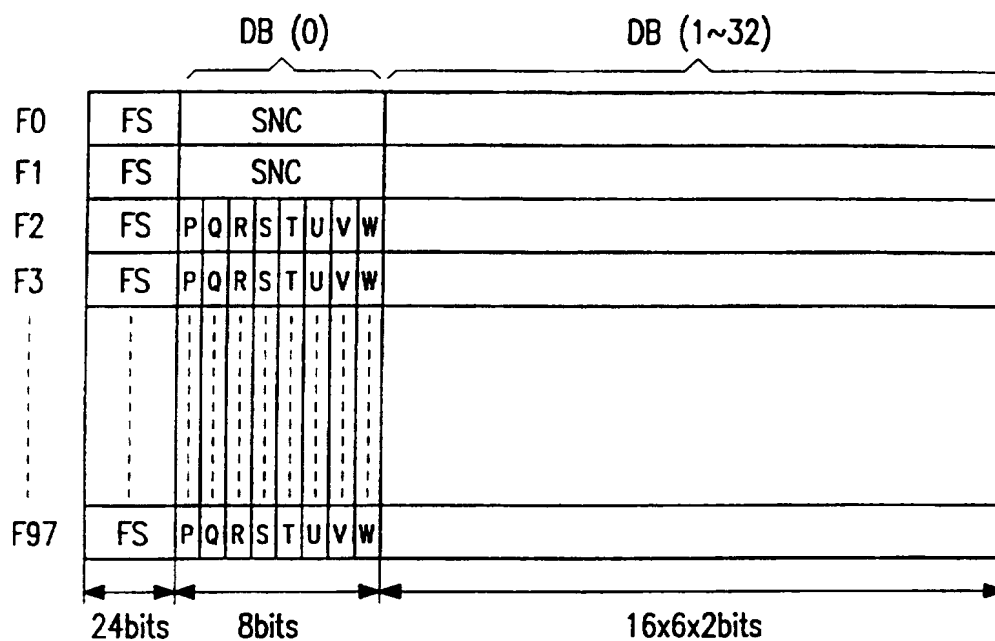


FIG. 2

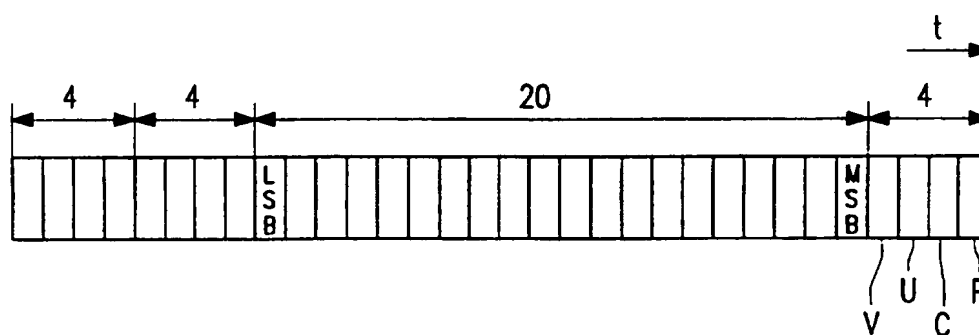


FIG. 5

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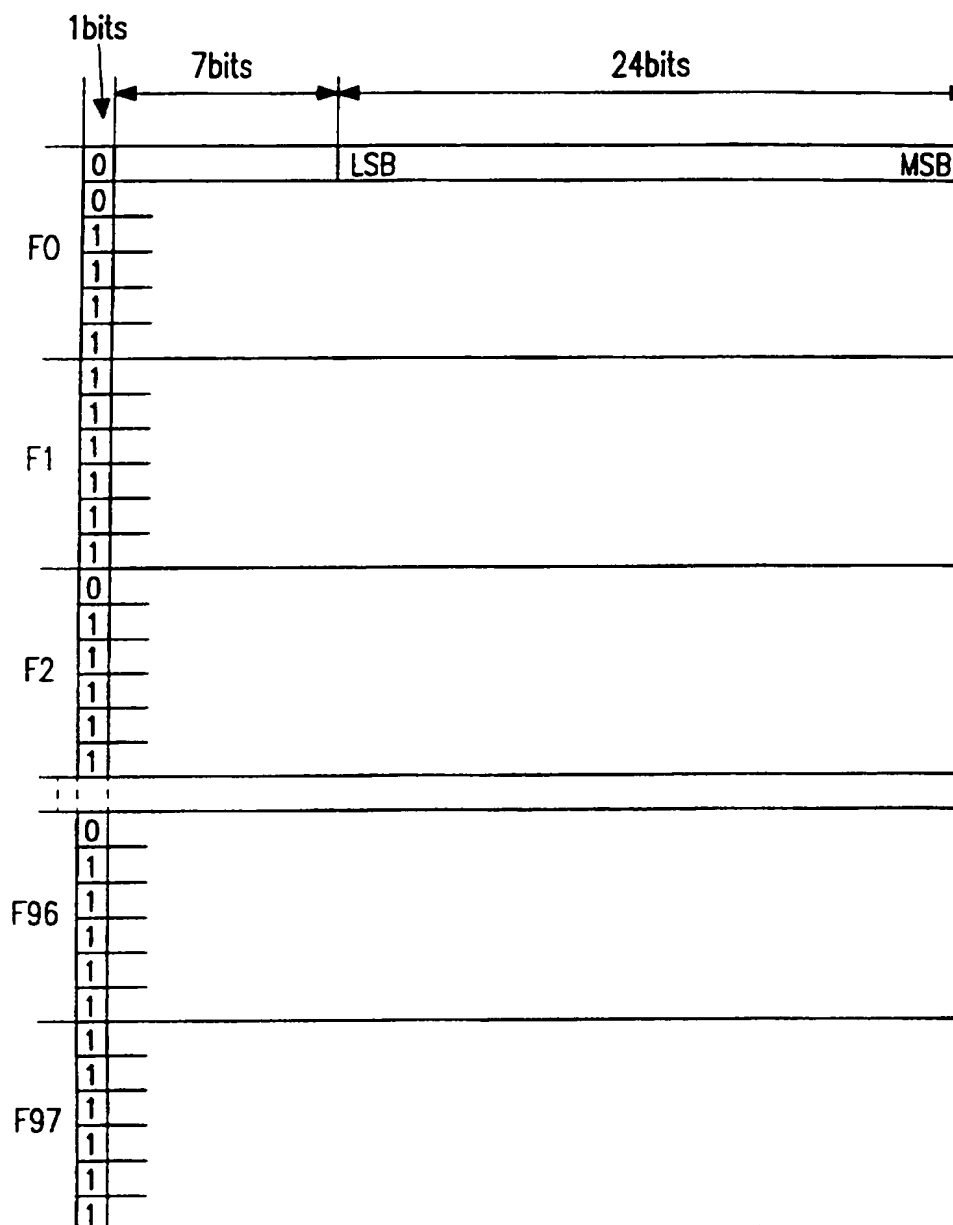


FIG. 3

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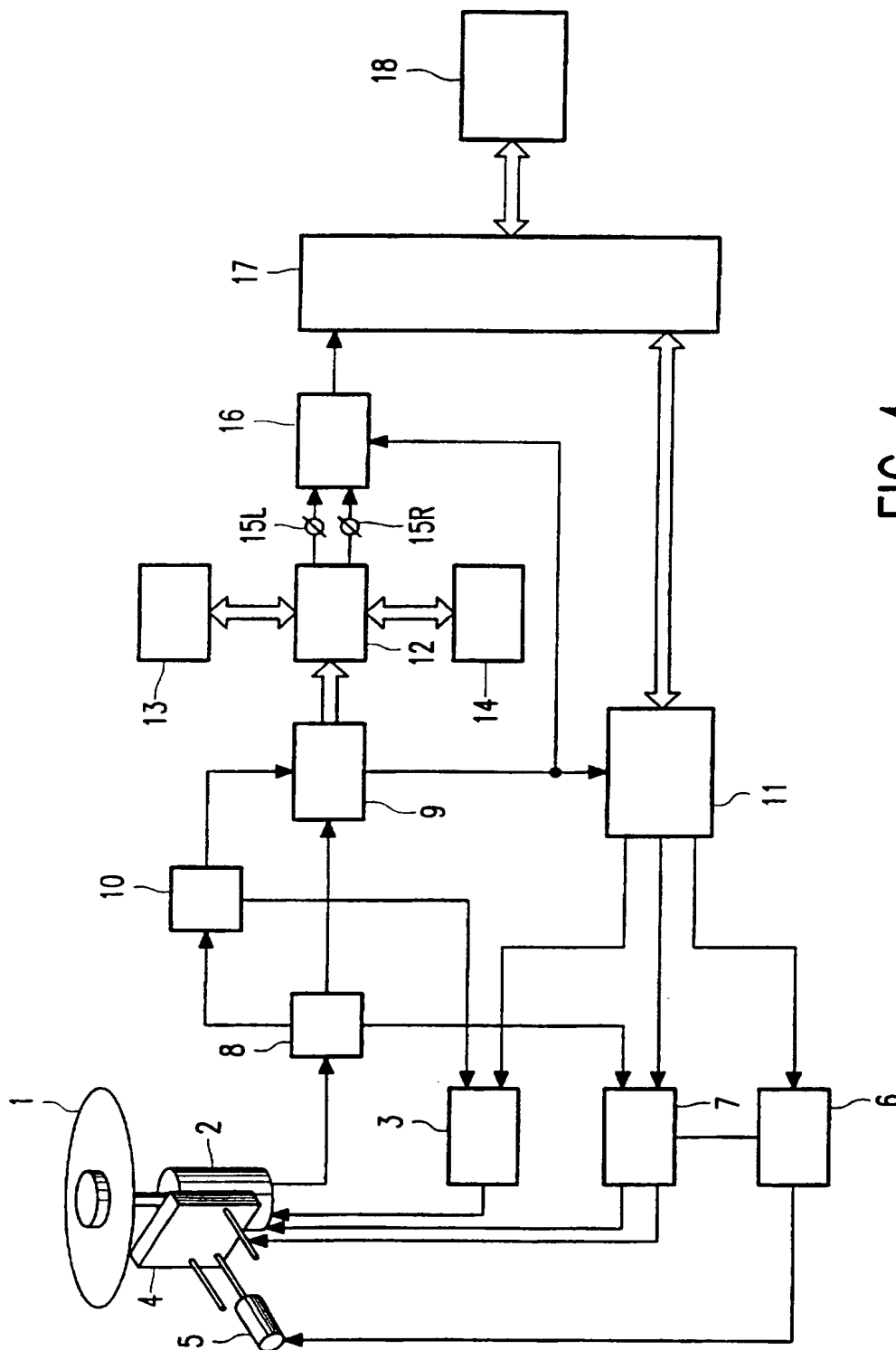


FIG. 4

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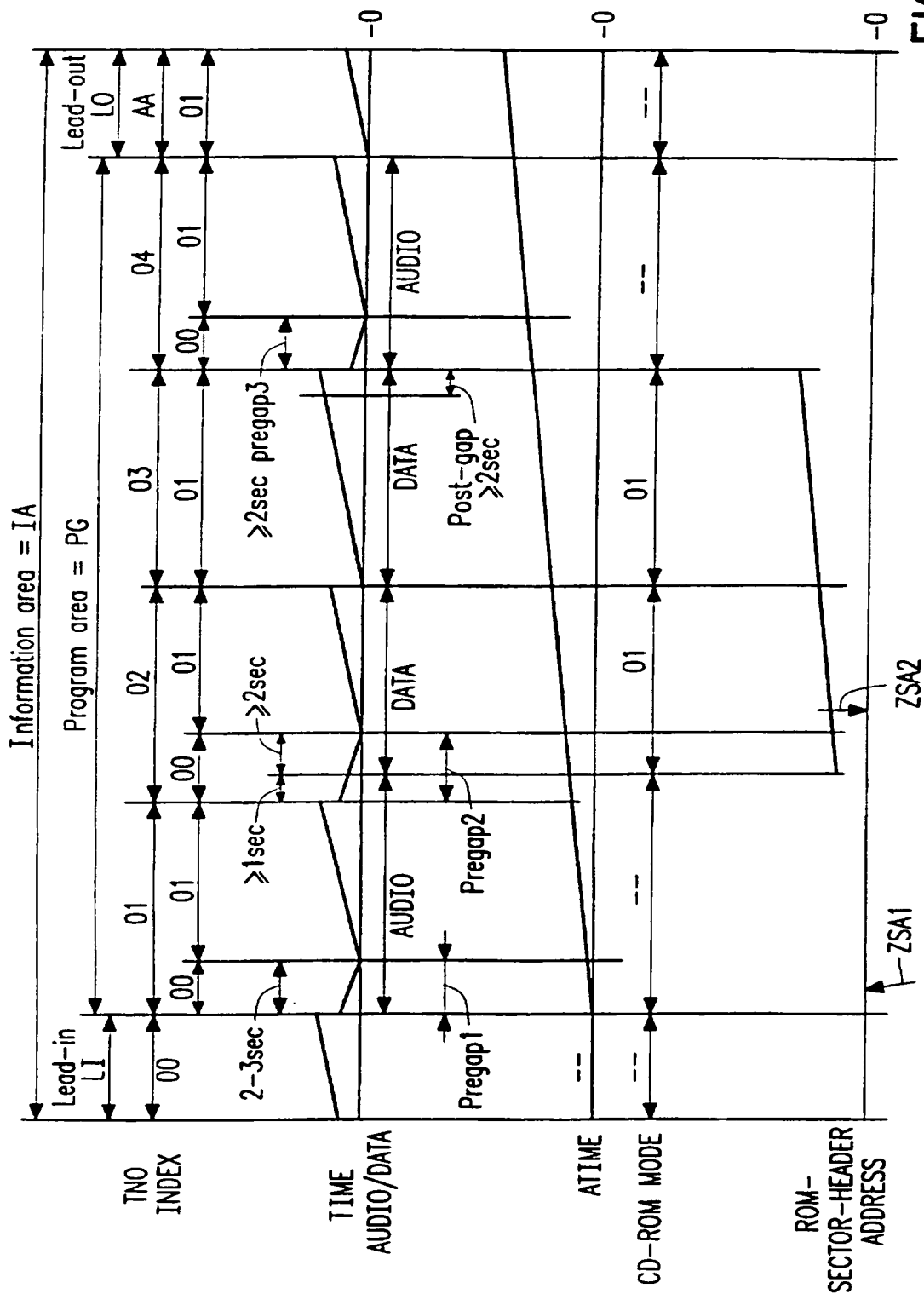


FIG. 6

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Layout of copy-protected CD-ROM

Address	Sector	Track	Index	Content	Comments
00:00:00		1	0	Zeros	Start of 150 sectors Pregap
00:00:01		1	0	Zeros	
00:00:02		1	0	Zeros	
-----		1	0	Zeros	
00:00:74		1	0	Zeros	
00:01:00		1	0	Zeros	
00:01:01		1	0	Zeros	
00:01:02		1	0	Zeros	
-----		1	0	Zeros	
00:01:73		1	0	Zeros	
00:01:74		1	0	Zeros	
00:02:00	0	1	1	Zeros	First readable sector on CD-ROM
00:02:01	1	1	1	Zeros	
00:02:02	2	1	1	Zeros	
-----		1	0	Zeros	
00:02:15	15	1	1	Zeros	
00:02:16	16	1	1	PVD	Primary Volume Descriptor
00:02:17	17	1	1	PVD	Primary Volume Descriptor
00:02:18	18	1	1	Zeros	No reference to these sectors
-----		1	0	Zeros	in the directory of the CD-ROM
00:02:24	24	1	1	Zeros	
00:02:25	25	1	1	Zeros	
00:02:26	26	1	1	Zeros	
00:00:00	27	1	1	Zeros	Address 00:02:27 missing
00:00:00	28	1	1	Zeros	Address 00:02:28 missing
00:00:00	29	1	1	Zeros	Address 00:02:29 missing
00:02:30	30	1	1	Zeros	
00:02:31	31	1	1	Zeros	
00:02:32	32	1	1	Zeros	
-----		1	0	Zeros	
00:02:73	73	1	1	Zeros	No reference to these sectors
00:02:74	74	1	1	Zeros	in the directory of the CD-ROM
00:03:00	75	1	1	Data	User data
00:03:01	76	1	1	Data	User data
00:03:02	77	1	1	Data	User data
00:03:03	78	1	1	Data	User data
-----		1	1	Data	User data
78:59:73	355348	1	1	Data	User data
78:59:74	355349	1	1	Data	User data
79:00:00	355350	1	1	Zeros	Postgap
-----		1	1	Zeros	Postgap
79:01:74	355499	1	1	Zeros	Postgap
79:02:00	355500	AA		Zeros	Start Leadout, End of CD

ADD ↑ SN ↑ TNO ↑ INDEX ↑

FIG. 7

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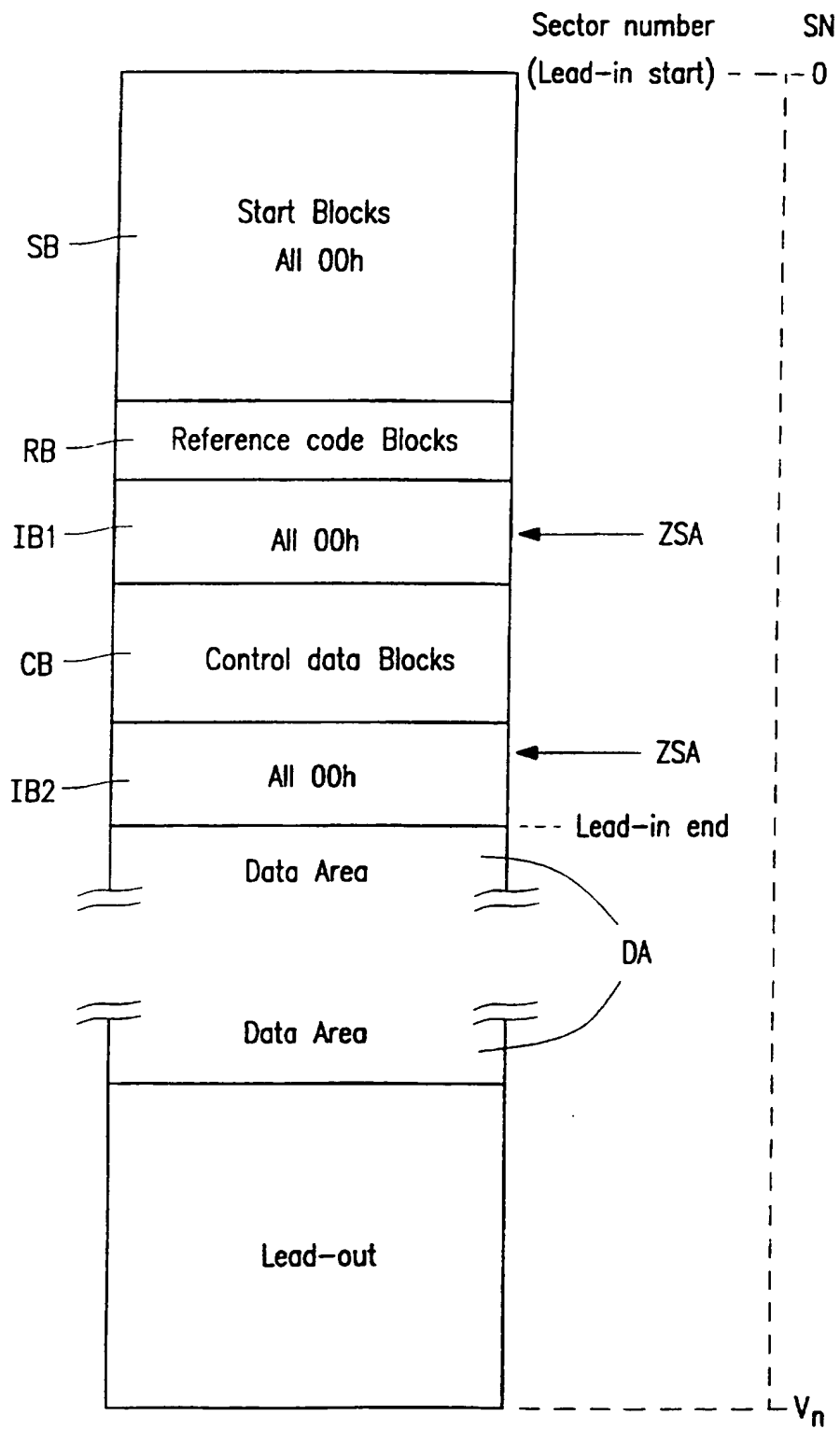


FIG. 8

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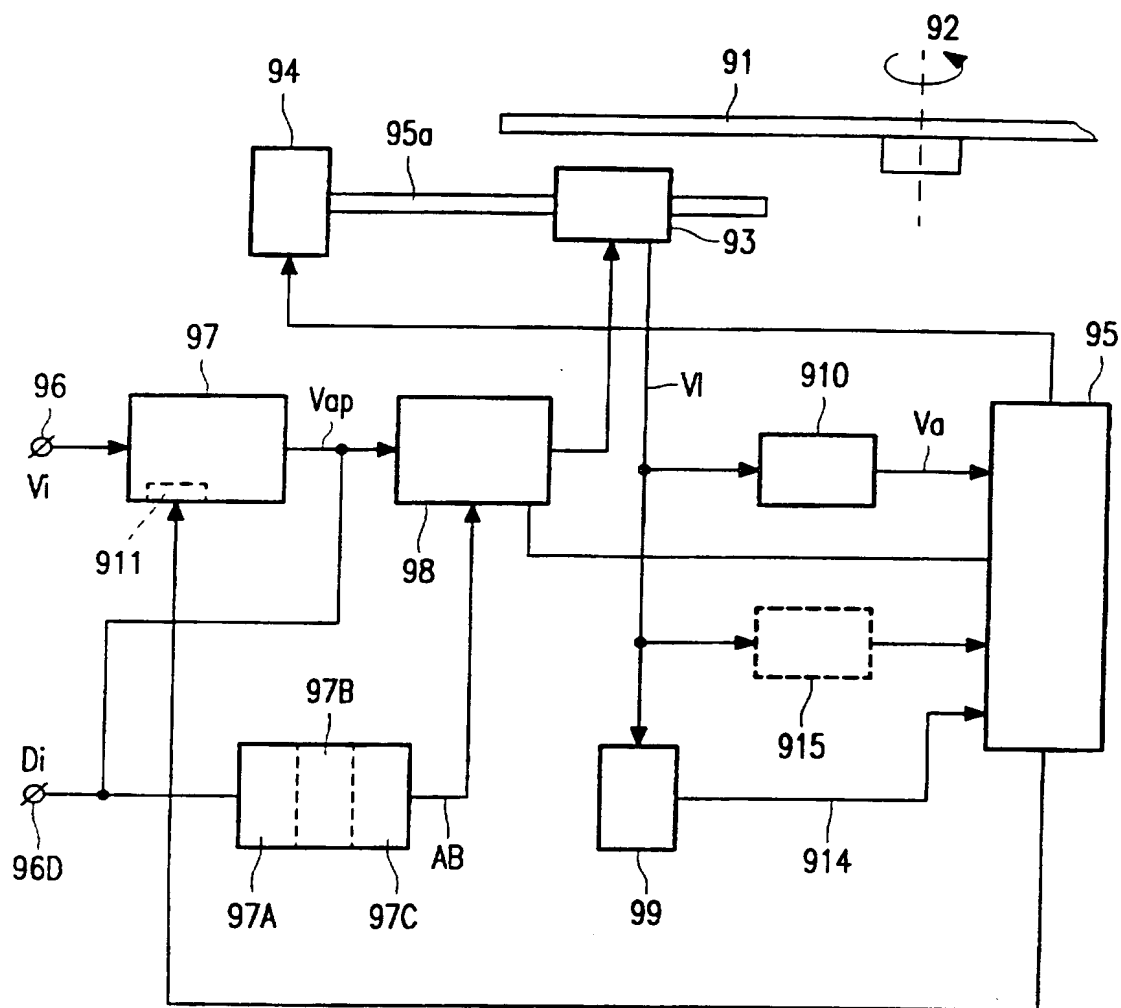
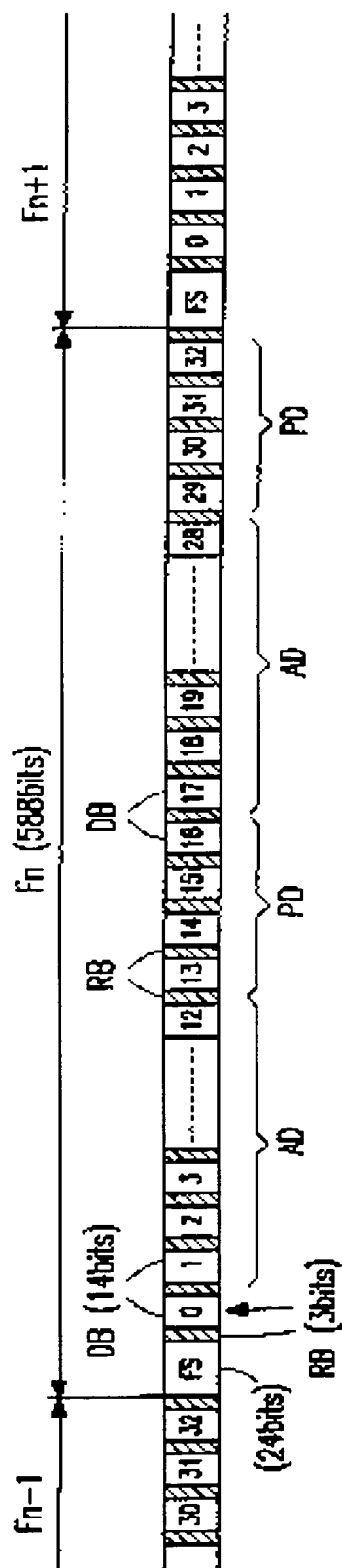


FIG. 9

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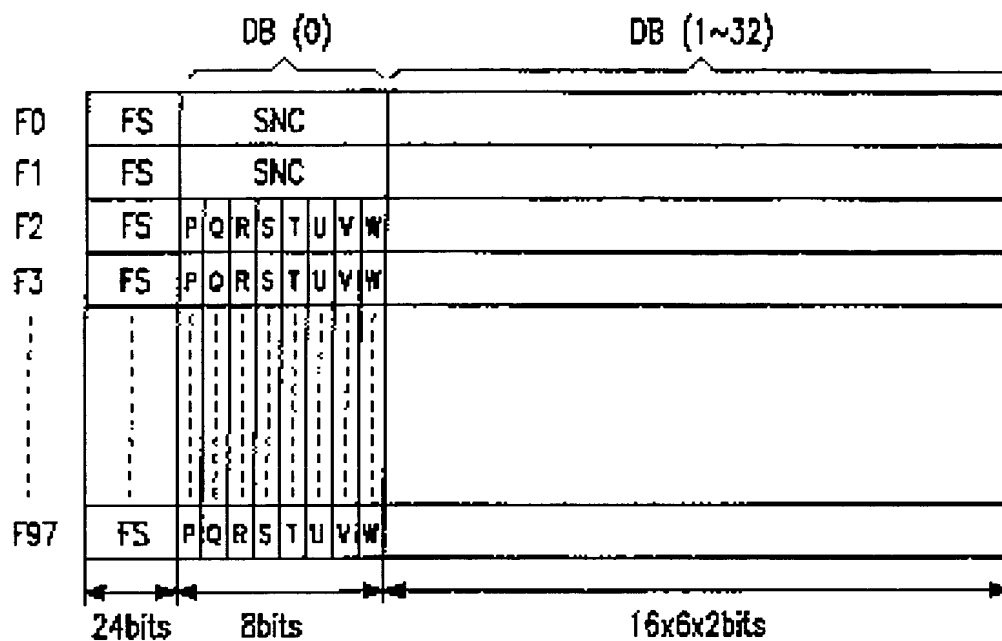


FIG. 2

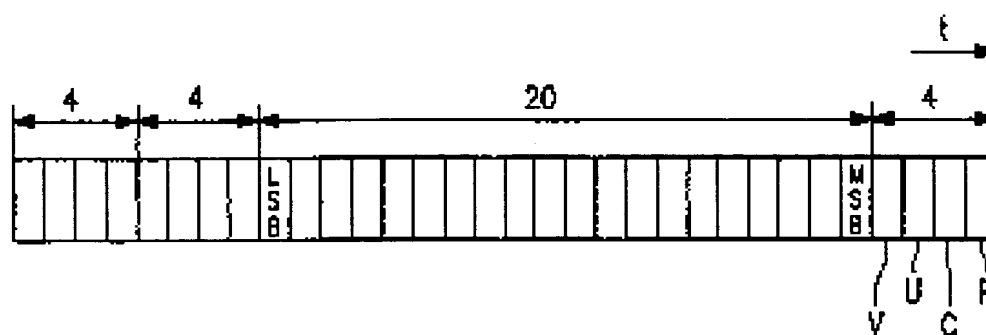


FIG. 5

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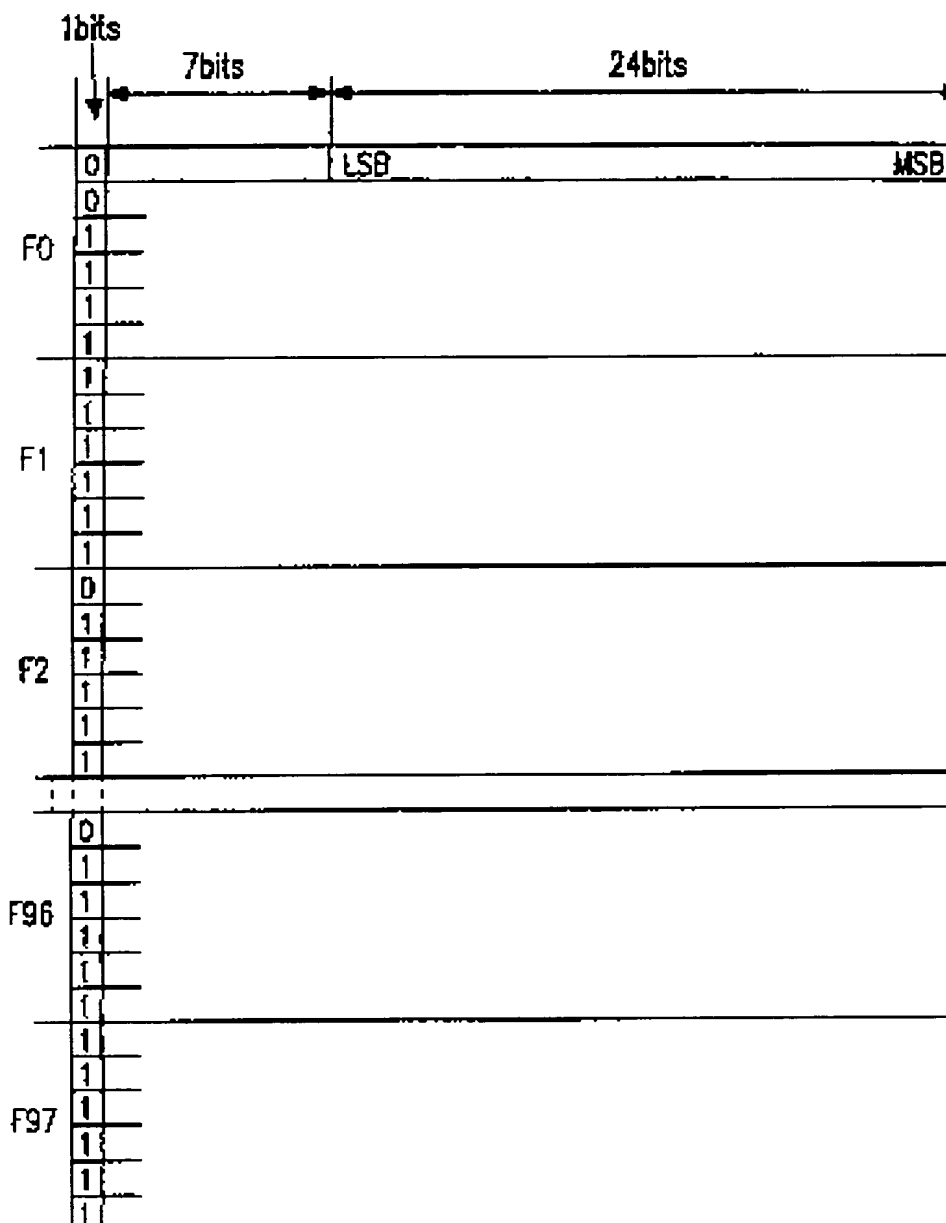


FIG. 3

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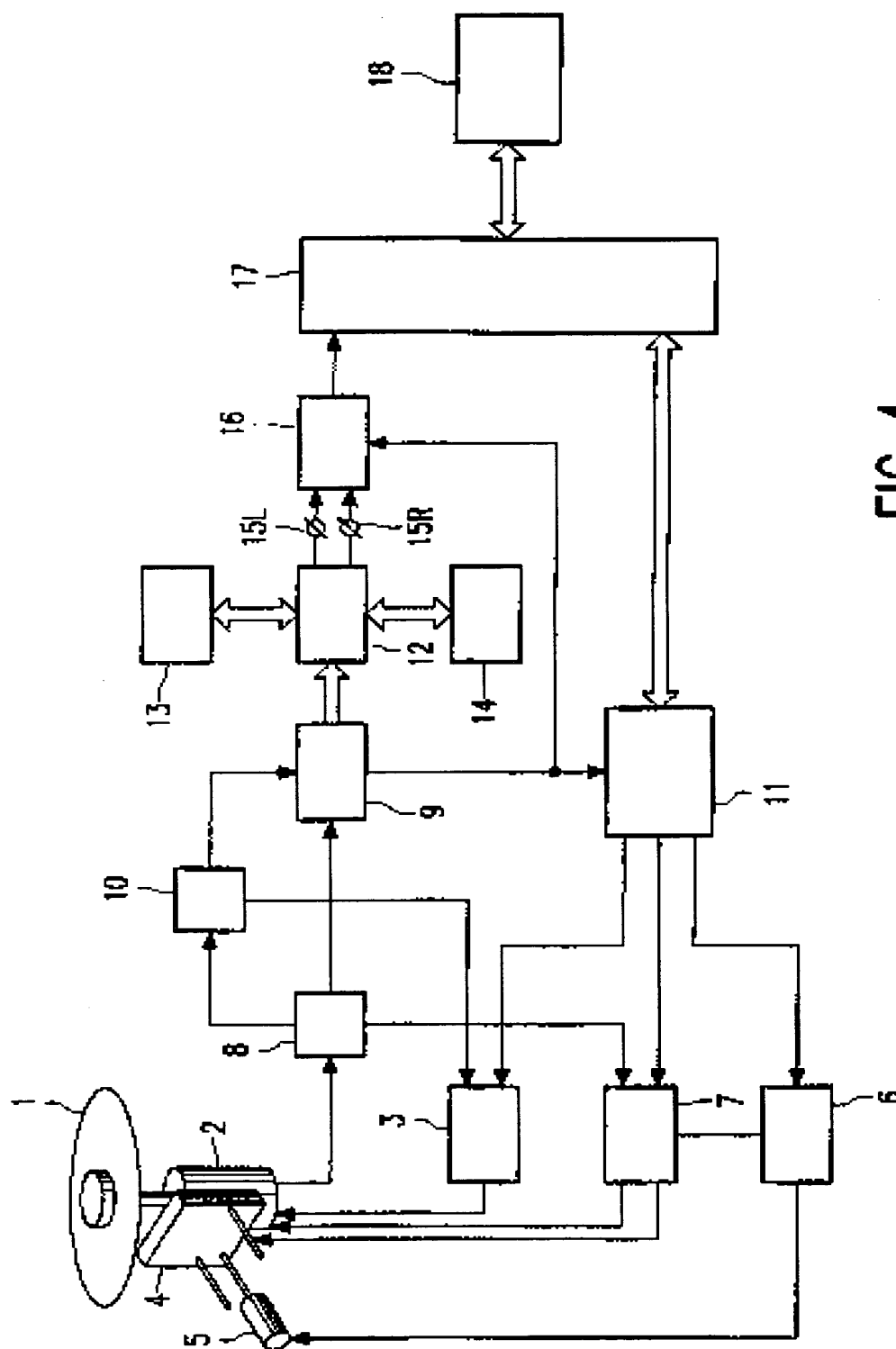


FIG. 4

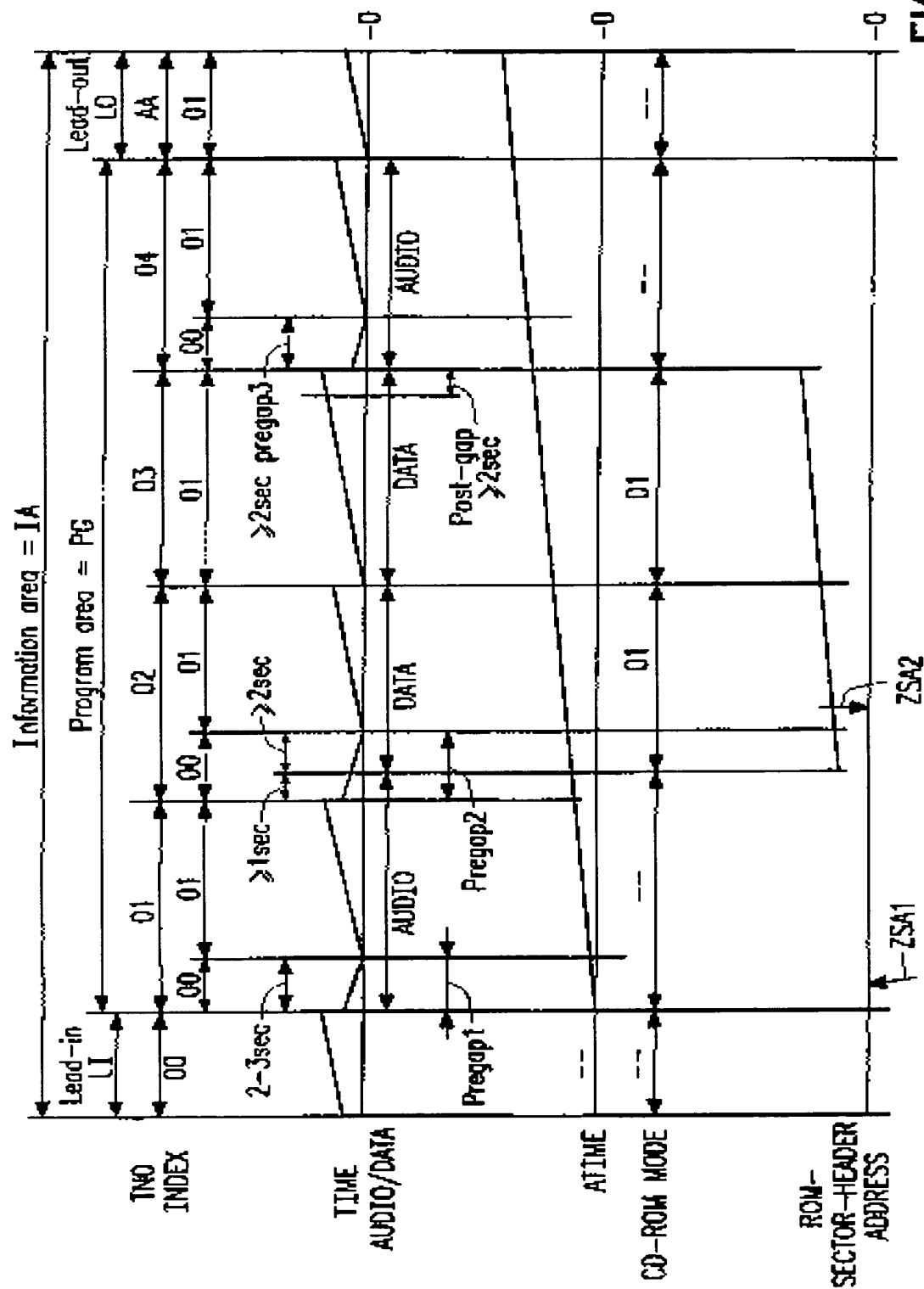


Fig. 6

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Layout of copy-protected CD-ROM

Address	Sector	Track	Index	Content	Comments
00:00:00		1	0	Zeros	Start of 150 sectors Pregap
00:00:01		1	0	Zeros	
00:00:02		1	0	Zeros	
-----		1	0	Zeros	
00:00:74		1	0	Zeros	
00:01:00		1	0	Zeros	
00:01:01		1	0	Zeros	
00:01:02		1	0	Zeros	
-----		1	0	Zeros	
00:01:73		1	0	Zeros	
00:01:74		1	0	Zeros	
00:02:00	0	1	1	Zeros	First readable sector on CD-ROM
00:02:01	1	1	1	Zeros	
00:02:02	2	1	1	Zeros	
-----		1	0	Zeros	
00:02:15	15	1	1	Zeros	
00:02:16	16	1	1	PVD	Primary Volume Descriptor
00:02:17	17	1	1	PVD	Primary Volume Descriptor
00:02:18	18	1	1	Zeros	No reference to these sectors
-----		1	0	Zeros	in the directory of the CD-ROM
00:02:24	24	1	1	Zeros	
00:02:25	25	1	1	Zeros	
00:02:26	26	1	1	Zeros	
00:02:27	27	1	1	Zeros	Address 00:02:27 missing
00:02:28	28	1	1	Zeros	Address 00:02:28 missing
00:02:29	29	1	1	Zeros	Address 00:02:29 missing
00:02:30	30	1	1	Zeros	
00:02:31	31	1	1	Zeros	
00:02:32	32	1	1	Zeros	
-----		1	0	Zeros	
00:02:73	73	1	1	Zeros	No reference to these sectors
00:02:74	74	1	1	Zeros	in the directory of the CD-ROM
00:03:00	75	1	1	Data	User data
00:03:01	76	1	1	Data	User data
00:03:02	77	1	1	Data	User data
00:03:03	78	1	1	Data	User data
-----		1	1	Data	User data
78:59:73	355348	1	1	Data	User data
78:59:74	355349	1	1	Data	User data
79:00:00	355350	1	1	Zeros	Pregap
-----		1	1	Zeros	Pregap
79:01:74	355499	1	1	Zeros	Pregap
79:02:00	355500	AA		Zeros	Start Leadout, End of CD

ADD ↑ SN TNO ↑ INDEX ↑

FIG. 7

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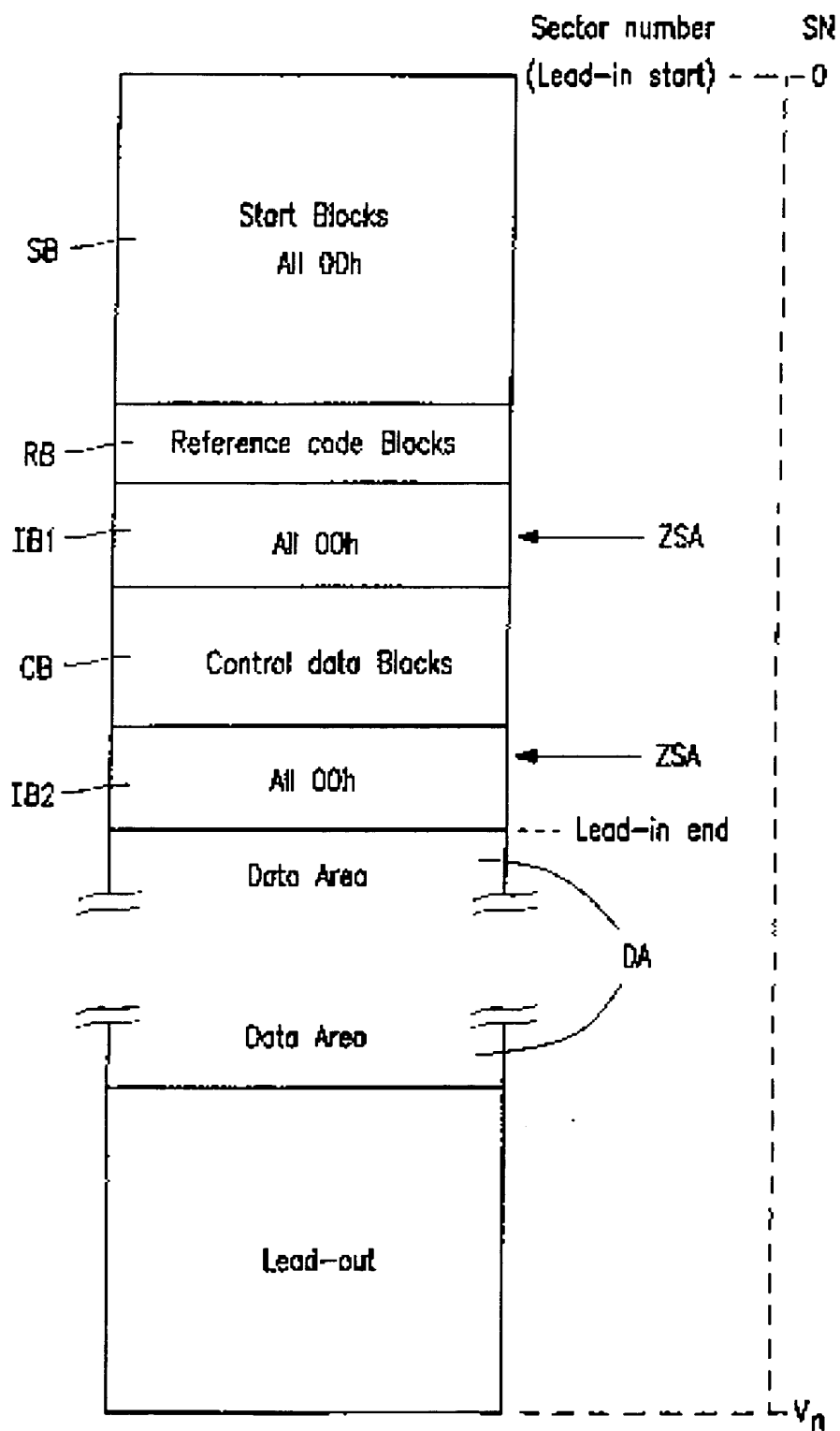


FIG. 8

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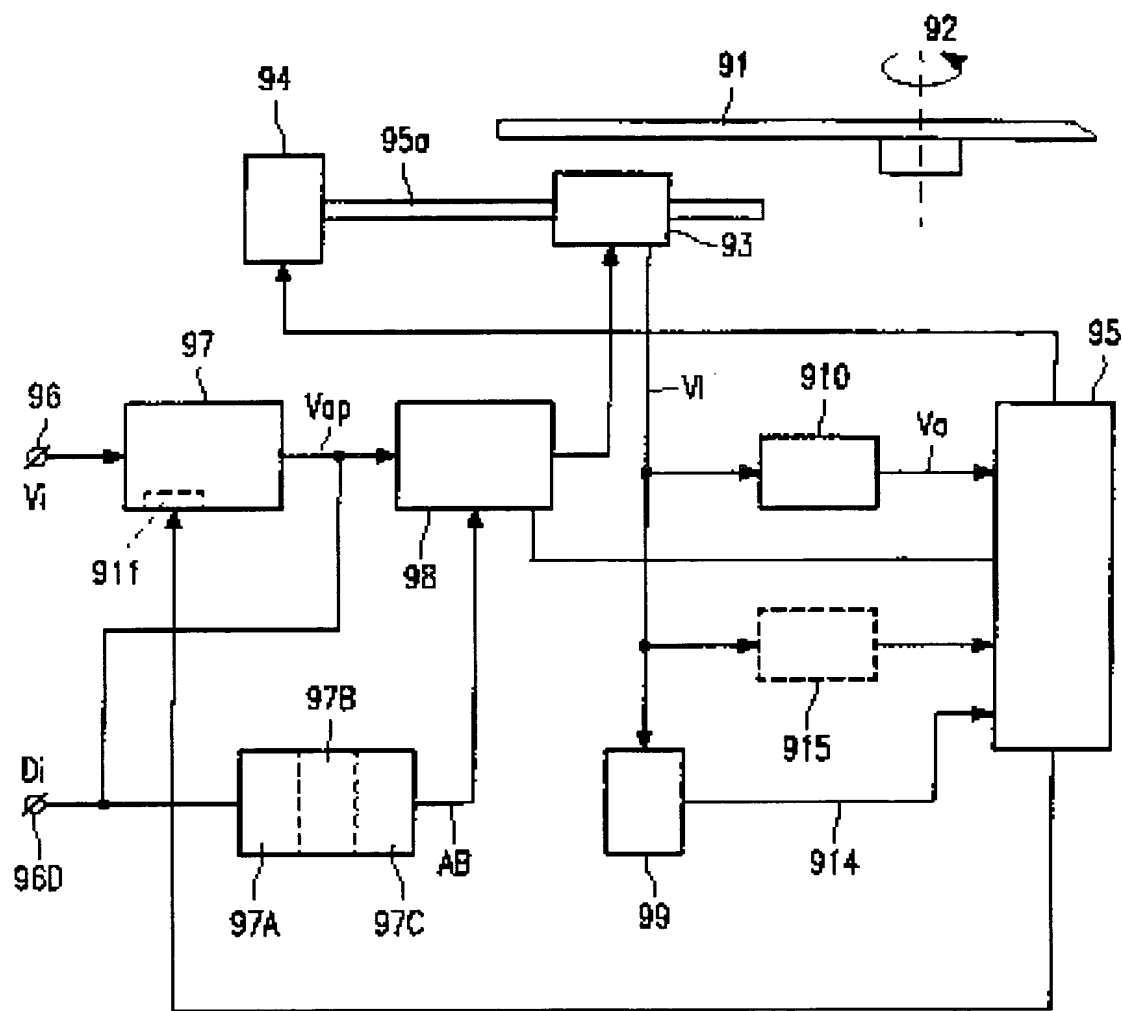


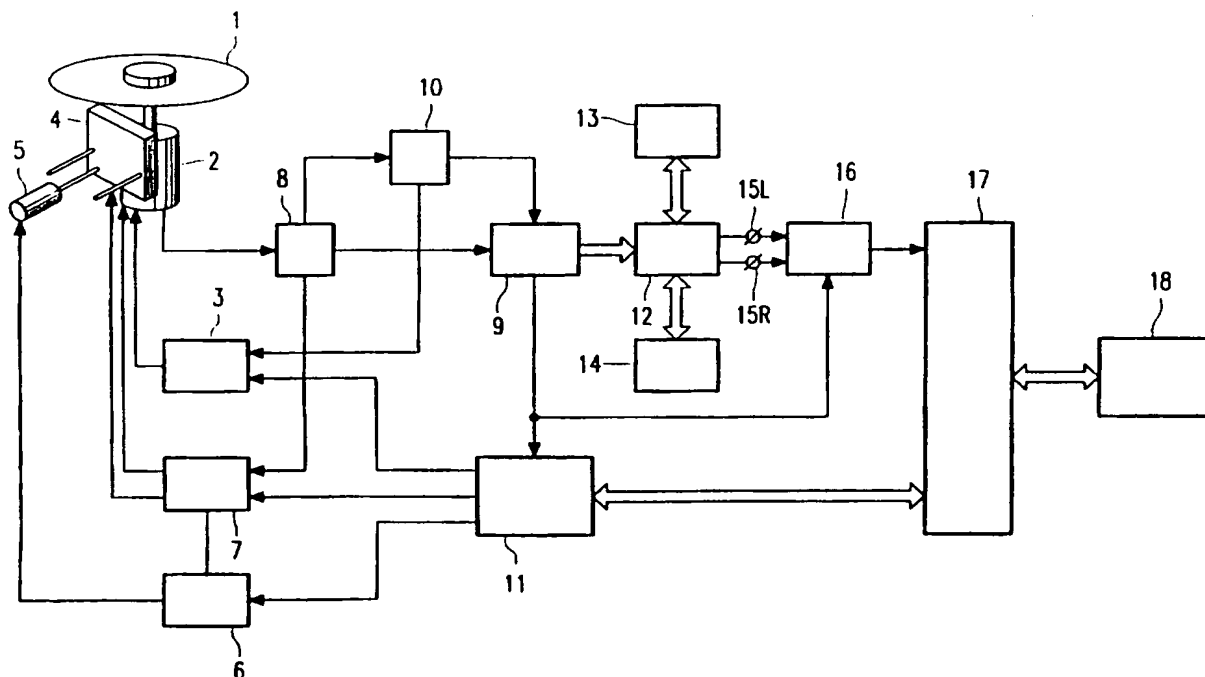
FIG. 9



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(30) Priority Data: 96202110.1 24 July 1996 (24.07.96) EP		Published <i>With international search report.</i>	
(34) Countries for which the regional or international application was filed: NL et al.		<i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	
(71) Applicant: PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).		(88) Date of publication of the international search report: 19 March 1998 (19.03.98)	
(71) Applicant (for SE only): PHILIPS NORDEN AB [SE/SE]; Kottbygatan 7, Kista, S-164 85 Stockholm (SE).			
(72) Inventors: SPITZENBEGGER, Uwe; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). FAESSEN, Louis, Marie, Hubertus; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).			
(74) Agent: FAESSEN, Louis, M., H.; Internationaal Octrooibureau B.V., P.O. Box 220, NL-5600 AE Eindhoven (NL).			

(54) Title: IMPROVEMENTS IN AND RELATING TO OPTICALLY READABLE DISCS AND DISC RECORDING APPARATUS



(57) Abstract

An optical disc and an optical disc recording apparatus have been disclosed, which provide an improved protection against undesired or illegal copying. Information on optical discs is arranged in sectors, which each has an address label. The address value of the address labels increases linearly from the start of the disc or from the start of the program area of the disc. The address labels of specific sectors, which may have an informationless content, are given different, e.g. zero, address values, which prevent copying CD-ROM discs on a standard CD-Recorder apparatus. Said address labels may be stored in the main data stream or e.g. the subcode channel of a CD system.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/00867

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G11B 7/007, G11B 20/10, G11B 27/28
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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IPC6: G11B

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPAT, WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y		3
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Date of the actual completion of the international search

27 January 1998

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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